CLAIMS

What is claimed is:

1. For a wavelength division multiplexed optical network having a plurality of optical nodes coupled by spans with each optical node capable of receiving at least one optical pre-amplifier for each input fiber and at least one optical post-amplifier for each output fiber, a computer implemented method of selecting amplifier placement, the method comprising:

selecting an optical power criterion for constraining placement of one or more optical amplifiers in the optical network, the optical power criterion being indicative of a sufficient minimum received power in at least one receiver;

placing at least one amplifier in accord with the optical power criterion to form an initial placement of amplifiers; and

determining a set of amplifier placement configurations which are consistent with the initial placement of amplifiers.

2. The method of claim 1, wherein the optical power criterion comprises:

placing an amplifier in a pre-selected node location responsive to an optical loss associated with at least one portion of a lightpath of the network exceeding a threshold loss.

3. The method of claim 1, wherein the optical criterion comprises:

analyzing the power level of at least one wavelength channel from a source node and placing an amplifier at a node location prior to a first node location in which the power level decreases below a threshold power level.

4. The method of claim 1, wherein the optical power criterion comprises:

calculating an aggregate loss for all of the spans and all of the nodes; and

forming a constraint on the number of amplifier required in the optical network by determining an aggregate number of amplifiers required for the aggregate optical loss.

5. The method of claim 1, further comprising:

performing a quality of service analysis upon each of the amplifier placement configurations; and

selecting the amplifier placement configuration having a desired level of service and a minimum number of optical amplifiers.

6. An optical network designed by the method of claim 5.

7. An optical network designed by the method of claim 1.

8. For a wavelength division multiplexed optical network having a plurality of optical nodes coupled by spans with each optical node capable of receiving at least one optical pre-amplifier for each input fiber and at least one optical post-amplifier for each output fiber, a computer implemented method of selecting amplifier placement, the method comprising:

selecting a plurality of light paths of the optical network;

for each selected light path, placing optical amplifiers in node locations requiring optical amplification to form an initial placement of amplifiers; and

determining a set of amplifier placement configurations which are consistent with the initial placement of amplifiers.

9. The method of claim 8, wherein an optical amplifier is placed in a node location responsive to an optical loss associated with at least one portion of the lightpath exceeding a threshold loss.

10. The method of claim 8, further comprising:

analyzing the power level of at least one wavelength channel from a source node and placing an amplifier at a node location prior to a first node location in which the power level decreases below a threshold power level.

11. The method of claim 8, further comprising:

calculating an aggregate loss for all of the spans and all of the nodes; and

forming a constraint on the number of amplifiers required in the optical network by determining an aggregate number of amplifiers required for the aggregate optical loss.

12. The method of claim 8, further comprising:

performing a quality of service analysis upon each of the amplifier placement configurations; and

selecting the amplifier placement configuration having a desired level of service and a minimum number of optical amplifiers.

13. An optical network designed by the method of claim 12.

14. An optical network designed by the method of claim 8.

15. A computer implemented method for designing a wavelength division multiplexed optical network, the method comprising:

providing an interface for a user to input an arrangement of optical nodes coupled by optical fiber spans, each of the optical fiber spans having an associated optical fiber loss that is dependent upon its length and upon an attenuation characteristic of the span;

each node having a minimum and a maximum number of possible optical pre-amplifiers which may be coupled to each of its input ports and a minimum and a maximum number of possible optical post-amplifiers which may be coupled to each of its

output ports, the optical network having an associated multiplicity of possible optical amplifier placement configurations;

for each node of the optical network, configuring optical components of optical add/drop multiplexers to add, drop, and pass through optical wavelength channels according to a channel map for providing services in the optical network, the optical components of the node having an associated optical loss characteristic;

selecting a set of optical amplifier placement configurations;

analyzing quality of service for each optical amplifier placement configuration in the set of optical amplifier placement configurations; and

selecting an optical amplifier placement configuration having a minimum number of optical amplifiers and a desired quality of service.

16. The method of claim 15, wherein selecting the set comprises:

selecting an optical power criterion for constraining placement of one or more optical amplifiers in the optical network, the optical power criterion being indicative of a sufficient minimum received power in at least one receiver;

placing at least one amplifier in accord with the optical power criterion to form an initial placement of amplifiers; and

determining a set of amplifier placement configurations which are consistent with the initial placement of amplifiers.

17. The method of claim 15, wherein selecting the set comprises:

for a node having at least one channel passing through the node, determining a pass-through optical loss associated with the at least one channel passing through the optical node;

responsive to the pass-through optical loss exceeding a threshold loss, placing at least one amplifier in the node.

18. The method of claim 15, wherein selecting the set comprises:

for at least one optical wavelength channel, forming an equivalent optical circuit model having an associated equivalent optical loss to couple a wavelength channel from a first node to a second node in the network; and

responsive to the equivalent optical loss exceeding a threshold optical loss, placing an optical amplifier in at least one of the nodes.

19. The method of claim 18, wherein the first and second nodes comprise an optical add/drop path, the minimum equivalent loss includes the losses along the add/drop path, and the optical amplifier is placed in one of the nodes along the add/drop path.

20. The method of claim 15, wherein selecting the set comprises:

for at least one optical wavelength channel that is added and dropped, sequentially moving from an add node to each subsequent node along an optical path to a drop node;

at each node in the sequence of nodes along the optical path, determining if an optical amplifier is required to couple the optical wavelength signal to a subsequent node; and

responsive to determining that an optical amplifier is required to couple the optical wavelength channel to a subsequent node, placing an amplifier in a node location selected to couple the optical wavelength signal to the subsequent node.

21. The method of claim 20, further comprising:

performing a power analysis of the wavelength channel along the optical path for an initial optical amplifier configuration; and

responsive to the wavelength channel having a power level below a threshold power level in a node, placing an optical amplifier in a previous node.

22. The method of claim 15, wherein selecting the set comprises:

placing amplifiers proximate high loss regions of the optical network.

23. The method of claim 15, wherein selecting the set further comprises: eliminating from consideration amplifier configurations belonging to branches of a decision tree likely to have unacceptably low power for at least one wavelength channel in at least one node.

24. The method of claim 15, where selecting the set comprises:

placing an optical amplifier in a node, responsive to the optical loss of the node for at least one pass-through channel exceeding a first threshold loss; and

placing at least one amplifier proximate one end of a span responsive to determining a path loss for a wavelength channel added in a first node traveling along an optical path including the span to a second node exceeding a second threshold loss.

25. The method of claim 24, further comprising:

forming configurations having at least one additional optical amplifier.

26. The method of claim 15, wherein selecting the set further comprises:

calculating an aggregate optical loss for all of the spans and all of the nodes; and

forming an estimate of the number of amplifiers required in the optical network by determining an aggregate number of amplifiers required for the aggregate optical loss.

27. An optical network designed by the method of claim 15.

28. A network design tool for a wavelength division multiplexed optical network in which each optical node is capable of receiving a plurality of optical amplifiers, comprising:

selection means for placing at least one optical amplifier to form an initial placement of amplifiers in accord with an optical power criteria;

means for forming a set of optical amplifier placement configurations in accord with the initial placement of the selection means; and

quality of service means to analyze the quality of service of each amplifier placement configuration.

29. A network design tool, comprising:

a network configuration module for configuring optical components of nodes of an optical network to add, drop, and pass-through wavelength channels according to a channel map;

an amplifier placement selection module for selecting a subset of amplifier placement configurations from the set of all possible amplifier placement configurations; and

a quality of service analysis module configured to analyze the quality of service for each amplifier configuration of the subset of amplifier placement configurations and select an amplifier configuration having a minimum number of amplifiers and a desired quality of service.

30. The system of claim 29, wherein the amplifier placement selection module places amplifiers proximate high loss regions of the optical network

31. The system of claim 29, wherein the amplifier placement selection module eliminates from consideration amplifier configurations belonging to branches of a

decision tree likely to have unacceptably low power for at least one wavelength channel in at least one node.

32. A wavelength division multiplexed optical network, comprising:

at least four optical nodes coupled by fiber optic spans,

each node having an optical add/drop multiplexer and each node capable of receiving at least one optical pre-amplifier for each input fiber and at least one optical post amplifier for each output fiber;

at least one optical amplifier disposed in the nodes, wherein the configuration of the at least one optical amplifier is selected and validated by a design tool.

33. The network of claim 32, wherein the network provides OC-192 compliant services.

34. The network of claim 32, wherein the network has at least five nodes.

35. The optical network of claim 32, wherein the design tool performs the steps of:

selecting a subset of optical amplifier placement configurations;

analyzing quality of service for each optical amplifier placement configuration in the subset of optical amplifier placement configurations; and

selecting an optical amplifier placement configuration having a minimum number of optical amplifiers and a desired quality of service.